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TITLE OF THE INVENTION: Method and Apparatus For  
Managing Software Use

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

The present invention relates to a method of managing software that prevents illegal use of software such as computer programs and allows only appropriate users to use it and a system therefore.

10 2. Description of the Related Art

It is important to prevent illegal copying and illegal forging of software such as computer programs and to be able to distribute the software in a state where only appropriate users authorized to use it can use it. In the past, methods of using a password and methods of using a dongle or IC card have been adopted as countermeasures against such illegal use.

15 The former methods prevent the software from effectively operating without password input for the software at the start of operation of the software. This is realized by matching the input password against a pre-registered password in the software. Note that a secret key, e.g., is used as the password in many cases.

20 The latter methods distribute a dongle or IC card together with the software to match an identifier of the software with an identifier written in the dongle or IC card at the start of operation of the software. A secret key, e.g., is also normally used for the identifier. In this method, even if secret information in the software is deciphered, since it is impossible to use the software without the dongle or IC card, it can be said that it is a method of higher safety.

25 30 In the above method of using a password, the password (secret key) itself which is supposed to be managed so as not to be

leaked may nonetheless be intentionally or accidentally divulged to someone other than the appropriate user, and the software may then be illegally used. In actuality, such illegal use often occurs.

Also, even in the method of using a dongle or IC card,  
5 forging and copying of the dongle or IC card may be possible in some circumstances. There is a possibility that the software will be illegally used by forging and copying. Also, in this method, the dongle or IC card has to be re-distributed in accordance with software upgrades or other modifications to the software. Thus, the  
10 method has the disadvantage that processing becomes troublesome and costly.

Accordingly, an object of the present invention is to provide a method of managing software that can manage software use with a high level of safety, while enabling upgrades and changes to the  
15 software to be easily handled.

Another object of the present invention is to provide a software management system that can manage software use with a high level of safety, while enabling upgrades and changes to the software to be easily handled.

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## SUMMARY OF THE INVENTION

In accordance with the above objects, a method of managing software is provided including the step of provider encoding of the software to be provided to a user with information  
25 storage means prepared corresponding to the software for providing instructions to an apparatus for running the software, which information storage means is capable of being accessed by the apparatus in a connected state. The method further includes a step of storing predetermined first information inside the information  
30 storage means for each corresponding piece of software, wherein second information to be matched against the first information is

stored in the information storage means by using a secret key of an open key encoding format. Further steps include transmitting the encoded second information to the software user and having the software user decode the transmitted encoded second information by using the open key of the open key encoding format. Other steps include reading the first information from the information storage means, and then matching the first information against the decoded second information, and enabling use of the software when the information match.

10 In further accordance with the above objects, an apparatus for managing software is provided including information storage means for storing distributed software to be used and for storing predetermined first information for each of the stored software, the information storage means being accessibly connected via  
15 predetermined interface means. The apparatus also includes transmitting means for transmitting third information identifying software to a software provider when seeking authorization of use of the stored software, and receiving means for receiving  
20 information transmitted by the software provider including second information to be matched against the first information, wherein the second information is generated based on the third information encoded using an open key of an open key encoding format. The apparatus further includes decoding means for decoding the  
25 received encoded second information by using the open key of the open key encoding format, and matching means for matching the first information stored in the information storage means against the decoded second information. The apparatus also includes execution control means for enabling the software to be used when the information match.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates preliminary processing of distribution in a program distribution system according to a preferred embodiment.

FIG. 2 further illustrates processing of a program distribution system according to a preferred embodiment.

5        FIG. 3 further illustrates in an exemplary embodiment preliminary processing of distribution in a program distribution system according to a preferred embodiment.

FIG. 4 is a flow chart for explaining processing for obtaining a prime number  $p$  in the exemplary embodiment of FIG. 3.

10       FIG. 5 is a flow chart for explaining processing for obtaining a primitive root  $g$  in the exemplary embodiment of FIG. 3.

FIG. 6 illustrates in an exemplary embodiment processing of a program distribution system according to a preferred embodiment.

## 15       DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be explained with reference to FIGs. 1 to 6. The preferred embodiment will be illustrated by describing a procedure by which a software sales company may sell software to users of the software with reference to FIG. 1.

20                First, a sales company 10 adds a password 11 to software that can identify the software by a product number, label name, etc., or inserts specific identification information 12 determined in accordance with modes of software such as a product number,  
25        dongle number, validity period (whether there is permanent right of use or right of use with a time limit of use), etc. in a dongle and distributes it to a user 20.

30                At this time, the sales company 10 manages a relationship among the password 11, identification information 12, and the user 20 to whom the software is distributed. Particularly, the identification information 12 is managed in a secret state to the third

party, i.e., the identification information is kept secret with respect to any third parties.

5           Next, the sales company 10 prepares a secret key 13 of an open key encoding mode only for the sales company and an open key 14 corresponding to it for the user 20. Then, the sales company 10 transfers the open key 14 corresponding to the secret key 13 to the user. The pair of keys 13,14 including the secret key 13 and the open key 14 prepared by the sales company may be commonly used for every user 20 or prepared differently for groups of users 20 or for each individual user 20. If the key pair 13,14 is made for common use among two or more users 20, management is easier than when a different key pair 13,14 is prepared for each user 20, while the more differently prepared key pairs 13,14 that are made relative to the number of users 20, the more that safety is improved. The sales company 10 can decide how to balance these countering considerations of ease of management and safety. Preferably, the open key 14 and secret key 13 to be used at this time use a digital signature method that is regarded as sufficiently safe.

20           Next, processing by which the user 20 actually obtains authorization of use and uses the software after completing the preliminary processing will be described with reference to FIG. 2. First, the user 20 transmits a password added to the software to the sales company 10 when trying to obtain a license, according to step 25 21. The sales company 10 searches through self-managed information according to the received password from the user 20 to detect and read identification information of the software of respective users in step 22. Next, the sales company 10 encodes the detected identification information by using a secret key of the sales company 10 to generate encoded license information in step 30

23. Then, the sales company 10 transmits the generated encoded license information to the respective users in step 24.

When receiving the encoded license information sent by the sales company 10 is step 24, the user 20 starts up the operation of the software and follows processing in the software to match the received encoded license information against identification information included in the a dongle or IC card in step 25. The software decodes the transmitted encoded license information by an open key and obtains the data corresponding to the password for respective users. Next, the software matches the license information against the identification information included in the dongle or IC card. When the information match, the software effectively starts to perform the desired processing according to step 26. However, when the information do not match, execution of the software is suspended according to step 27.

As above, in this preferred embodiment, a license is given by using the identification information included in the dongle or IC card. The information included in the dongle or IC card normally cannot be known or retrieved even by the user 20. Accordingly, it is possible to safely manage the use of the software in a desired form. In addition, the identification information which is transferred to the user in step 24 of FIG. 2 is in an encoded format, and this encoded license information is prepared only by the sales company 10 having the secret key. Therefore, even if a person learns the identification information, it is difficult to prepare encoded license information, so it is possible to manage licenses of software use with a high degree of security according to this preferred embodiment.

A more detailed explanation according to a specific example of the above embodiment is provided below. Note that in the description below, PN indicates a product number added to the software upon

its sale, DID indicates a dongle ID number, PID a product ID number, CK a center secret key, UK a user open key,  $h$  a unidirectional hash function, and (R, L) encoding license information. Note also that a case of using a Schnoor signature method will be described here as preferred, although one skilled in the art would understand that other methods are available and would work with the preferred embodiment described above with respect to FIGs. 1-2.

First, preferred preliminary processing at the sales company 10 will be explained with reference to FIG. 3. A prime number  $q$  of about 32 bits is selected. Then, a large prime number  $p$  of about 1024 bits is selected making the prime number  $q$  a prime factor of  $(p-1)$ . The obtained prime numbers  $p$  and  $q$  are recorded in the software and the dongle or IC card at step 31.

A preferred selecting method of the prime numbers  $q$  and  $p$  is described below with reference to FIG. 4. When the selecting processing starts at step S10 of FIG. 4, a prime number  $q$  of about 32 bits is selected by using a probability prime-number testing method such as the Rabin method at step S11. Next, the prime number  $q_0$  of about 320 bits is selected preferably in the same way by the probability prime-number testing method at step S12. Next,  $n=1$  is set at step S13 and the prime number  $q_n$  is further selected in preferably the same way by using the probability prime-number testing method at step S14. Then,  $a=2 \times q_0 \times \dots \times q_n$  is calculated at step S15. It is next checked whether the bit length of the calculation result  $a$ , which is defined as a probability prime-number testing parameter, reaches a predetermined bit length of about 1000 bits at step S16.

When the probability prime-number testing parameter  $a$  is determined to be less than 1000 bits at step S16, the index  $n$  is incremented up by 1 at step S17, and the procedure returns to the

processing from step S14. Namely, a next prime number  $q_n$  is further selected at step S14,  $a=2xq_0x \dots xq_n$  is calculated at step S15, and whether or not a bit length of the probability prime-number testing parameter  $a$  reaches a predetermined bit length of about 1000 bits is checked at step S16. The loop may be repeated as many times as it takes until the probability prime-number testing parameter is determined to be about 1000 bits.

When the bit length of the probability prime-number testing parameter  $a$  reaches a predetermined bit length of about 1000 bits, as determined at step S16, by repeating the processing,  $p=qx2xq_0x \dots xq_{n+1}$  is calculated at step S18. Then, it is judged by the probability prime-number testing method whether an obtained value  $p$  is a prime number or not at step S19. When it is judged at step S19 that the obtained value  $p$  is not a prime number, the procedure returns to step S12 and processing from step S12 to step S18 is repeated for obtaining a new value  $p$ . These steps may be repeated as many times as it takes until the obtained value of  $p$  is determined at step S19 to be a prime number. When the obtained value  $p$  is determined at step S19 to be a prime number, the processing is ended at step S20.

Referring back now to FIG. 3, a primitive root  $g$  for the value  $p$  is selected, wherein  $h=g^{(p-1)/q} \bmod p$  is calculated, and this information is recorded in the software and the dongle according to step 32 of FIG. 3. The preferred processing for selecting the primitive root  $g$  is described below with reference to FIG. 5. Note that, in this description, it is defined that  $p-1=r_1x \dots xr_n$ .

First, after the processing is started at step S30 of FIG. 5, the primitive root  $g$  fulfilling  $1 < g < p$  is selected at random in step S31. Next,  $i=1$  is set at step S32. Then,  $a=g^{(p-1/r_1)}$  is calculated at step S33 (where  $g^{(p-1/r_1)}$  indicates in step 33 shown at FIG. 5 that  $g$  is raised to the  $\{(p-1)/r_1\}$  power). Now, whether the

probability testing parameter  $a$  satisfies  $a \neq 1 \bmod p$  or not is checked at step S34.

When  $a = 1 \bmod p$  stands as a result of the checking at step S34, the procedure returns to step S31, and the processing from selecting the primitive root  $g$  starts again, and the steps S31 through S34 are repeated until  $a \neq 1 \bmod p$  is found as a result of checking at step S34. When  $a \neq 1 \bmod p$ , it is then checked whether all  $r_i$  are checked, that is, it is checked whether or not  $i = n$  at step S35. When it is determined that  $i \neq n$ , then  $i$  is incremented at step S36, and the procedure returns to the step S33, and steps S33 through S35 are repeated until it is determined at step S35 that  $i = n$ , including incrementing at step S36 each time it is determined that  $i \neq n$  at step S35. When all  $r_i$  are checked such that it is determined at step S35 that  $i = n$ , then the processing is ended by setting the primitive root  $g$  obtained at that time as an actual/primitive root at step S37.

Referring back now to FIG. 3, a secret key CK of the sales company is selected freely so as to satisfy  $0 < CK < q$  at step 33 of FIG. 3. The secret key CK is preferably stringently kept secret for sole use by the sales company 10. Next, a user key UK is calculated based on formula (1), below, about which the user 10 is notified at step 34. The user open key UK is preferably generated and the user 20 is notified at the time of sale of the software for the first time, then again each time the software is upgraded.

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$$\text{[Formula 1]:} \quad UK = h^{(p-1-CK)} x \bmod p \quad \dots(1)$$

Next, a product number PN, a dongle ID number DID corresponding thereto, and a product ID number PID are recorded on a dongle at steps 35 and 36. The product ID number PID belongs to the software and is stringently kept for sole use by the

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sales company 10. A unidirectional Hash function  $H$  (1x value region of  $Hxq$ ) is prepared and recorded in the software and in the dongle at step 37. The above is the specific content of the preferred preliminary processing performed at the sales company 10.

Next, a preferred method of managing licenses and managing execution of the software on the user's side will be specifically explained with reference to FIG. 6. First, the user transmits a product number  $PN$  to the sales company 10 when purchasing the software or updating an expiration date for using the software at step 61. The sales company obtains a  $DID$  and  $PID$  of the software of the user 20 at step 62 based on the product number  $PN$  transmitted by the user 20 to the sales company 10 at step 61. Next, the sales company 10 generates a random number  $k$  ( $1 < k < q$ ), generates encoded license information  $(R, L)$  in accordance with Formula 2, below, and transmits the same to the user at step 63.

[Formula 2]:  $R = H(DID, PID, h^k \bmod p)$ , for  $0 < R < q$ , and  
 $L = CK \times R + k \bmod p$  (2)

The user uses the received encoded license information  $(R, L)$  and the product number  $PN$  and reads from the dongle a  $DID$  and  $PID$  corresponding to the production number  $PN$  to perform matching as shown in the formula 3, below at step 64.

[Formula 3]:  $H(DID, PID, H^L \times UK^R \bmod p) = R$  (3)

Then, when Formula 3 holds, the matching is determined to be a success, the user 20 is confirmed to be an appropriate user and the operation of the program is made to be validly run at step

65. However, when Formula 3 does not hold and the matching fails, then operation of the program is stopped at step 66. The above embodiment can thus be implemented by the preferred specific processing set forth above.

5                   Note that the present invention is not limited to the preferred embodiment set forth herein, and a variety of modifications can be made within the scope of the invention as set forth in the claims below, and equivalents thereof. For example, the preferred embodiment was described with respect to a license  
10                   controlling method in the case of distributing a computer program as an example. However, the preferred embodiment may be applied to a variety of data uses other than programs, such as data in any system like a library or data having a functional structure. In addition, the preferred embodiment may be applied to programs  
15                   and data used in a machine, system, etc. other than a computer.

                  Also, an example of using the Schnoor signature method was described in the above specific example, but another digital signature format may be used, such as an RSA signature, DSA signature, ElGmal signature, Fiat-Shamir signature, and an ellipse  
20                   curve-based signature. Also, an example of particularly distributing a dongle with software was described in the preferred embodiment, but an IC card or other similar device known to those skilled in the art may be used instead of a dongle. Note that the processing of the sales company 10, the user 20, etc. were described in the  
25                   above example, but the actual processing is preferably performed in an information processing apparatus on the sales company's side and an information processing apparatus on the user's side.

                  According to the preferred embodiment, the objects of the invention are met. That is, a method of managing software capable  
30                   of managing software use with a high degree of safety and ease of handling upgrades or other changes is provided herein. Also, a

software management system capable of managing software use with a high degree of safety and ease of handling upgrades or other changes is provided herein.

5 While exemplary drawings and specific embodiments of the present invention have been described and illustrated, it is to be understood that that the scope of the present invention is not to be limited to the particular embodiments discussed. Thus, the embodiments shall be regarded as illustrative rather than restrictive, and it should be understood that variations may  
10 be made in those embodiments by workers skilled in the arts without departing from the scope of the present invention as set forth in the claims that follow, and equivalents thereof.

In addition, in the method claims that follow, the steps have been ordered in selected typographical sequences.  
15 However, the sequences have been selected and so ordered for typographical convenience and are not intended to imply any particular order for performing the steps, except for those claims wherein a particular ordering of steps is expressly set forth or understood by one of ordinary skill in the art as being  
20 necessary.